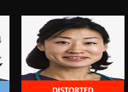

High Speed Streams and Space Weather Forecasting

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ABSTRACT

The Space Weather Research Center provides experimental research forecasts and analysis for NASA robotics missions operators. Space weather forecasters monitor space weather conditions to provide advance warning and forecasts based on observations and modeling. High speed streams (HSS) are a type of space weather driver involving the high speed component of the solar wind that originates from coronal holes, which can last for many solar rotations. High speed streams produce geomagnetic storms with different source signatures than those of geomagnetic storms caused by coronal mass ejections (CMEs).

Coronal mass ejections are studied extensively and are well known for producing strong geomagnetic storms and impacting Earth's radiation belts. High speed streams pump energy into the Earth's magnetosphere for a longer period of time than that of a flux rope, producing energetic electron flux enhancement in Earth's outer radiation belt (near geosynchronous orbit) and prolonged substorm activity. It is important to understand high speed streams as a driver of space weather activity due to the energetic electron enhancement that can impact spacecraft in the near-Earth environment.

This project will focus on the high speed stream events on June 8, 2015, July 4, 2015, and July 10, 2015, in order to understand the different arrival signatures, impacts on electron flux enhancement, and development of geomagnetic storms from high speed streams.

BACKGROUND

High speed streams are associated with the high speed solar wind that originates from coronal holes

Coronal holes are regions with open magnetic fields and are commonly found at the poles

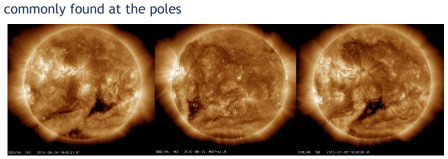


Figure 1. A coronal hole lasting one solar rotation was responsible for high speed streams on June 8, 2015 and July 4, 2015.

Stream interaction regions (SIRS) are found at the compressed boundary of high and slow speed solar wind.

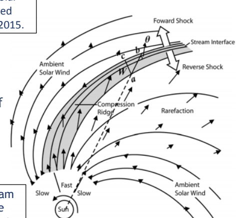


Figure 2. A 2-D diagram of a stream interaction region is shown in the gray area. It is wound less tightly in the Parker spiral than the ambient solar wind. *L.K.Jian et al.*

Co-Rotating Interaction Regions (CIRS) is a high speed stream that lasts many solar rotations over a long-lasting coronal hole

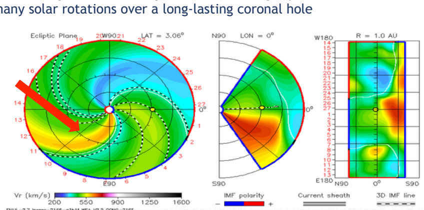


Figure 3. A long-lasting stream interaction region as shown in the WSA-ENLIL cone model by the difference in velocity from the ambient solar wind. *Image credit: iSWA*

High Speed Streams vs. Coronal Mass Ejections

High Speed Streams

- Electron flux enhancement at GEO orbits
- Outer edge radiation belt impact is more prominent
- Weaker, long geomagnetic storms (3-6 days)

Coronal Mass Ejections

- Radiation belt flux peak more inside GEO orbits
- More magnetic field coupling
- Strong geomagnetic storms

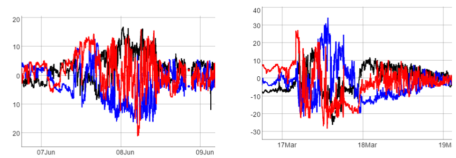


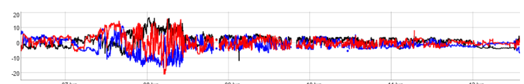
Figure 4. The different source signatures for the June 7th, 2015 High Speed Stream arrival and the March 17th, 2015 CME arrival at ACE *image credit: iSWA*

OBSERVED EVENTS and METHODOLOGY

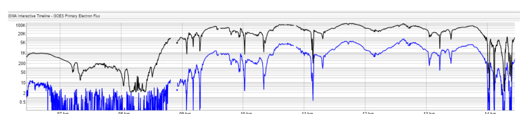
HSS Event: 2015-06-08T00:16Z

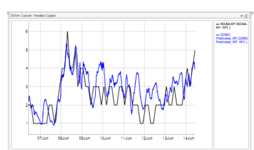
Peak solar wind velocity: 712 km/s

Ace Magnetic Field



GOES electron flux





The Kp rose to 6 on 2015-06-08 and quickly quieted down, going back to 3 within the next 24 hours.

Two days later there was a magnetopause crossing on 2015-06-10

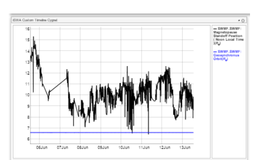


Figure 5. A progression of events from the June 8, 2015 high speed stream event *image credit: iSWA*

July: A Month of High Speed Stream Activity

Solar wind velocity for three high speed streams as shown at ACE

Electron flux enhancement as measured by GOES

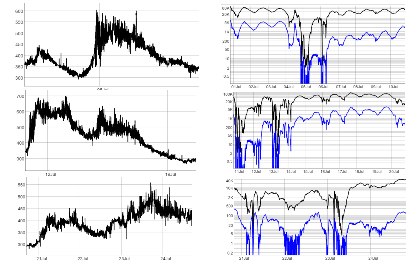


Figure 6. Four high speed stream events in the month of July *image credit: iSWA*

The Earth's Magnetosphere

Changes in the solar wind (like a HSS) produce electron flux enhancements by adding energy to the Earth's magnetosphere.

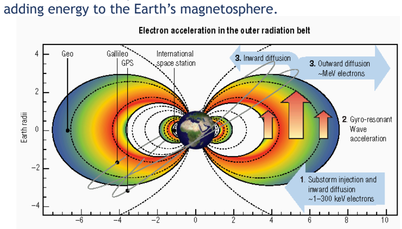
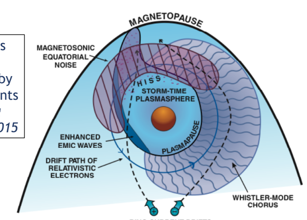


Figure 7. High speed streams accelerate electrons in the outer radiation belt, leading to substorms in the near-Earth environment *image credit: Horne et al., 2007, Nature Physics*

Figure 8. Various waves dynamics found in the radiation belt, driven by high speed stream events *image credit: Y. Zheng RB/SEP PowerPoint, 2015*



FORECASTING HIGH SPEED STREAMS

Short term forecasting of high speed streams can be done by studying the coronal holes on the Sun and their magnetic field structure.

Co-rotating interaction regions can indicate when a coronal hole will rotate onto the Earth-facing solar disk, usually about every 25-27 days.

ACKNOWLEDGEMENTS

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